The Journal
of the
Mysore Agricultural
and
Experimental Union.

Vol. XI. 1930. No. 3

Groundnut in Mysore.

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The Mysore State lies between 11° 36′ and 15° 2′ North Latitude, and 74° 38′ and 78° 36′ East Longitude. It lies between the Eastern and Western Ghats in the Peninsular India. The two ranges of the ghats converge and form the elevated table-land of the Nilgiris in the southern part of the State. The highest point of this table-land is over 8,000 feet. The average elevation of the plateau of Mysore itself is over 2,000 feet.

The State of Mysore has an area of 29,474 square miles or is nearly as big as Scotland. The population is nearly 6,000,000 and the main industry of the people is agriculture. A considerable amount of cotton and silk goods are manufactured. The gold mines of Kolar maintain a large population. The iron works, manganese and chrome mining are other major industrial activities in the State. But the stability of the State depends upon favourable monsoons and the prosperity of the rural population.

The following table gives the total area of the State and the relation between the forests, cultivated lands and areas unfit for cultivation. Nearly a sixth of the area fit for cultivation is well protected by irrigation works.

In 1925—1926.*

	Acres.
Total area	17,574,227
Area unfit for cultivation	6,952,588
Forests	1,940,667
Cultivable waste	670,348
Area under occupation	8,010,623
Fallow during the year	1,625,225
Actual area cropped	6,720,049

Out of the area cropped, nearly 1,076,398 acres are irrigated and sometimes on these lands two or more crops are raised in a year wherever water is available.

In 1925-1926, out of the total cropped area of 6,720,049 acres, nearly 5,380,129 acres or 80 % were under food crops. The rest of the area was under oil-seeds, fibres, sugarcane, condiments and a number of miscellaneous crops.

The most important crops in 1925-1926 were as follows :—

	Acres.
Ragi (*Eleusine coracana*)	2,253,859
Rice	709,369
Jowar (*A. sorghum*)	624,501
Horse-gram (*Dolichos biflorus*)	704,500
Oil-seeds	594,367
Fibres	95,151
Condiments	137,960

During the same year the following commercial crops, securing ready cash to the cultivator, were cultivated :—

*Subsequent years had abnormal seasonal conditions and have therefore not been considered here.

	Acres.
Groundnut	213,095*
Coffee (Coffee is purely a plantation product. The planters are either European settlers or Indians)	103,498
Cotton	83,000
Areca nut	51,643
Mulberry (for rearing silk worms)	42,320
Sugarcane	32,999
Tobacco	30,531
Mangoes	13,169
Potatoes	5,500

It is seen from the tables given above that Ragi (*E. coracana*) is the most important crop. It is the staple food grain crop of the State and often over 3 million acres of this grain are cultivated. The improvement of ragi was the first problem taken up for investigation by the botanical section of the State Agricultural Department in 1913. Previous to this year a number of cultural, manurial, crop rotation and seasonal sowing experiments were conducted on the State Agricultural Experiment Station at Hebbal. The experiments amongst other results revealed the two following facts :

1. Autumn ploughing or ploughing after the harvest of ragi was over, resulted in a bigger crop of ragi in the next year.

2. A crop of groundnut in rotation with ragi was superior to avare (*Dolichos lablab*).

The following table gives the results of rotation experiments carried over a period of four years :—

	Yield of grain per acre in lbs. Average of 4 years.
Ragi after ragi	1,153
Ragi after *Dolichos lablab*	1,316
Ragi after groundnut	1,466

* The area under groundnut in 1929-30 was over 300,000 acres.

There was an increase of 313 lbs. of ragi per acre by growing groundnut in rotation with it, representing an increase of about 27% in the yield of grain. At present ragi is grown year after year and the fear that by the extension of groundnut cultivation there would be a shrinkage in the production of ragi is groundless. For, with an increase of about 27% in the yield of ragi by growing groundnut in rotation, it is possible to displace about 675,000 acres or 700,000 acres of ragi without seriously affecting the food grain supply in the State. As a crop in rotation with jowar and as a garden crop, another 300,000 acres may be easily grown under groundnut in the State. Thus the maximum area under groundnut can ultimately be about one million acres. Taking 600 lbs. as the average yield per acre, and Rs. 7 per 100 lbs. of pods as the price, the approximate value of the total production will be about Rs. 42,000,000 or £3,000,000 per year. This would give about Rs. 7 per head of population effecting an increase in the earning capacity of the individual by nearly 20%; such is the importance of the crop to Mysore. Soil and climate are congenial, market for the produce is unlimited, but the industry requires capital and organization to attain its full development.

In the black cotton soil areas, where cotton is usually grown, the cultivator gets money by selling the seed cotton or lint. In places where sugarcane or other garden crops are grown, they supply the cultivator with ready money. Where silk industry is prosperous, growing mulberry pays the cultivator. But the cultivator of the Mysore red soil area, where only ragi is grown, has no commercial crop to sell. He is forced to sell a part of his food grains and pulses in order to pay taxes, to buy articles of necessity like salt, sugar, oils and clothes, and also to meet the expenses incurred during marriages and festivities. Introducing a commercial crop in the system of his farming had become an urgent necessity and fortunately groundnut has solved the problem to a great extent and I am persuaded to believe that it is going to solve the problem of his indebtedness to a considerable degree.

The following figures show clearly that groundnut was a crop of no importance before 1908 and its importance was recognized just before the Great War. As a result of the War there was a set-back to this industry, but during the last four years the extension has been very great, and the quantities exported have greatly increased,

Year	Exports Rs.	Imports Rs.
1905	..	11,000
1906	..	33,000
1907	..	31,000
1908	27,000	29,000
1909	11,000	1,35,000
1910	39,000	1,53,000
1911	2,37,000	54,000
1912	2,14,000	43,000
1913	6,09,000	27,000
1914	4,93,400	13,100
1915	71,900	76,100
1916	2,79,000	32,100

Year	Exports		Imports	
	Mds.	Rs.	Mds.	Rs.
1917	56,801	2,02,279	7,215	25,287
1918	27,964	1,35,356	30,623	1,47,287
1919	54,322	5,03,157	50,100	4,92,043
1920	77,717	9,59,274	45,345	5,53,193
1921	89,819	7,82,916	2,14,034	45,345
1922	1,59,340	14,74,682	16,699	1,49,323
1923	1,58,781	14,36,956	13,823	1,27,832
1924	1,05,122	22,99,940	26,877	5,96,375
1925	2,98,743	25,53,364	56,726	5,09,241
1926	3,81,612	30,26,297	57,075	4,57,657

(Each maund is $82\frac{2}{7}$ lbs.)

The statistics of area for groundnut prior to 1917 are not available. This area was merged in that given for the total area for oilseeds. The following figures show that the extension had reached 77,305 acres in 1917 and as a result of the War and cessation of export trade to Central Europe, the area dwindled down to 46,118 in 1919. Since 1920 there has been a revival in trade. But from 1924 to 1926 the expansion has been quite marked. And the indications are that during the last season much greater area has been put under groundnut than in any previous year. The expansion has been greatly found in the black cotton soils. In Chitaldroog district,

there were 7,020 acres in 1919 ; 39,447 acres in 1925, and 74,986 acres in 1926. Groundnut is seriously competing with cotton in these areas. There has been also an increase of nearly 43,000 acres in one year in Kolar.

In 1917—77,395 acres	In 1922— 86,120 acres
1918—67,775 ,,	1923— 90,114 ,,
1919—46,118 ,,	1924—1,02,345 ,,
1920—53,934 ,,	1925—1,27,583 ,,
1921—73,071 ,,	1926—2,13,095 ,,

The possibilities of groundnut as a commercial crop in Mysore were detected by the Department of Agriculture in 1914. The cultural and rotation experiments had shown the use of groundnut as a good legume fit for rotation in Mysore dry land farming. And the demand created for good and improved seed was great. It was to meet this demand experiments on groundnut and varietal tests were started in the year 1917.

All the preliminary observations and laboratory work were done by me in the central laboratory of the Department at Bangalore, and the field trials were conducted on the ragi breeding plots on the Hebbal Agricultural Experimental Farm.

The Hebbal Farm is 5 miles to the north of Bangalore in a broad valley, and is situated on the shores of a big tank or reservoir. The general elevation of the Farm is about 2950 ft. above the sea-level. In between Bangalore and the Farm runs the great water-shed which divides the basins of the rivers Krishna and the Cauvery. The soils of the Farm are sandy or sandy loams. Under the tank the soils are clayey loams lying over stiff clay.

In Mysore, the rainfall varies between 337 inches on the crests of the Western Ghats and 18 inches on the sweeping plains in the east. The general average for the whole of the open country is from 30 to 36 inches.

There is a slight difference between the conditions of Bangalore and the Hebbal Farm ; but they do not warrant separate treatment. I have therefore selected Bangalore to describe the weather conditions under which the experiments were conducted.

The following table gives the temperature, rainfall, humidity, amount of sunshine and wind velocity, during the Agricultural season

lasting from May to January. The figures are the averages for 20 years' observations.

BANGALORE

Month	Mean Temperatures			Cloud	Humidity	Wind daily Velocity	Rainfall	
	Max.	Min.	Normal				Inches	Number of days
				%	%	miles		
May ..	92.0	69.2	80.6	48	75	132	4.43	10
June ..	85.0	67.1	76.1	76	81	197	2.69	12
July ..	82.1	66.1	74.1	86	86	195	4.01	16
August ..	82.2	65.9	74.1	87	86	172	5.02	15
September..	82.5	65.8	74.2	80	86	132	8.23	16
October ..	82.3	65.3	73.8	61	82	104	5.27	13
November ..	80.2	62.1	71.2	52	79	117	2.55	8
December ..	79.2	58.4	68.8	37	80	131	0.42	3

The soil on which most of the experiments were conducted was a red sandy loam, with good subsoil drainage. In this part of Mysore there is hardly any difference between the soil and subsoil. Sometimes the depth of the soil is as much as 20 ft. The Hebbal red sandy loam holds 21% of its own weight of water and about 60% of this quantity is the optimum amount of moisture required in the soil for a successful growth of crop.

It has already been shown that the physical analysis of this type of soil was as follows :—

Gravel ..	.. 7.5 to 14.6%
Sand ..	.. 58.3 to 70.4%
Silt ..	.. 10.7 to 13.0%
Clay ..	.. 7.0 to 10.0%

The red soils are poor in humus, nitrogen and phosphoric acid. They are also poor in lime.

Nitrogen	.. 0.080%
Phosphoric acid	.. 0.083%
Lime	.. 0.190%

The breeding plots did not receive any farmyard manure for over fourteen years. To get the plots to an uniform condition, ragi has been rotated with groundnut and only twice during the period mentioned, a small dose of powdered groundnut cake was drilled into the ground just before sowing ragi.

The cultivation season usually begins in April or May soon after the first rains. If the land is soft after ragi is harvested, generally a disc harrow is passed. If the land is fit for ploughing, it is ploughed and then left fallow during the following summer. In April or May it is again ploughed, harrowed and made ready for sowing in June or July. Groundnut is usually sown in July, either in plough furrows or in drills. The fields are weeded and cultivated three or four times during the growth of the crop by hand implements and harvesting is done by hand.

When the work was taken on hand in 1917, a number of problems suggested themselves for investigation in the course of the work. As time and facilities were available one after another was taken up. Under general improvement of the crop the following points were investigated :—

1. Varietal tests to find out the relative productive capacity of various exotic varieties and indigenous ones.
2. The optimum space required for sowing in order to get the biggest yields of pods.
3. Water requirement of the groundnut plant.
4. Effect of lime on the development of pods and seeds.
5. Effect of soil on the quality of pods.
6. Effect of rainfall on the quality and production of groundnuts.
7. Seed selection.

Varietal Tests.

A variety known as "Mysore Local" has been under cultivation for over a century. It is a long duration type, taking five to six months to ripen. The pods are long and have many seeds. Usually the pod has two or three seeds. Four or five are not rare and I have even seen seven seeds on one occasion. The shell is very thin and highly reticulated with the markings of the venation. The seeds are supposed to be good for eating. It has a low oil content of 30 to 35% of oil and seems to contain more sugar than any other variety. The plants are bushy, branch freely, and the stems are prostrate in habit and are clothed with many hairs. This variety is very similar to some of the samples I have examined at Kew, among collections

from the Phillipines and Mexico. Probably it is related to the varieties now grown in Central and South America, and was the variety which came to Asia along with the Magellan Expedition. The lateness of maturity and poor yields do not make it a desirable variety for cultivation. Only market gardeners living near towns grow it for eating purposes.

Varieties introduced later into Madras, like Mauritius, Virginia, Spanish and Small Japan, have begun to spread in Mysore also. For many years varietal tests were carried on at Palur, in the Madras Presidency, by the Agricultural Department of Madras. Whenever there was a demand from the cultivators, the Mysore Department used to secure seeds from Palur for distribution. Prior to 1914, groundnut varieties were tested on the Hebbal Farm for two or three years and varieties like Virginia and Big Japan seem to have given encouraging results. At present Virginia and Mauritius have been very popular in the State. Since the trade is carried on in measures, big podded varieties are in favour. If the Chamber of Commerce could fix the value of groundnuts on the percentage of good seeds and on their oil content, the artificial boom for big-podded varieties will, in the course of time, vanish.

To start our varietal experiments we received all our samples from the Palur Agricultural Station in 1917. The following varieties were used in our experiments. They were all sown in rows, 12 inches apart, and the distance between plant and plant was about 6 inches. All the varieties were sown in small narrow strips running through the whole breadth of the plot and repeated three times. A local variety called Sogatoor was used as the check. There is no variety called Sogatoor on the market, but this one has been called so as it was collected at Sogatoor, a village in Kolar district. In reality it is an acclimatised variety of Mauritius. It is also believed that the variety which is known as Mauritius is only a variety from Mozambique, taken from Mozambique, in Portuguese East Africa, to Mauritius and from there on to Madras. Results of the various experiments are given below.

The following table gives the yields of varieties, percentage of kernel in their pods, percentage of oil and the total amount of oil obtained per acre from them :—

	Yield of pods per acre Average of 3 years. lbs.	Per cent of kernel to pod.	Per cent of oil.	Oil in lbs. per acre.
Local Sogatoor ..	1,256	77	47.97	478
Carolina ..	1,121	77	46.87	404
Barbados ..	1,111	72	44.65	350
Pondicherry ..	1,008	78	43.00	337
Big Japan ..	969	78	47.10	358
Mauritius ..	962	78	46.42	347
Transvaal ..	960	77	45.53	334
Brazil ..	849	79	47.21	314
Small Japan (Erect type) ..	517	79	50.23	206
Spanish (Erect type)	511	76	48.51	189

The varietal tests were started in 1917 with a collection of the most important commercial varieties received from Palur. Virginia was included in the tests in 1920. Local Sogatoor was used as the standard for comparison. It has given the highest yields so far and has proved to be superior to all exotic ones. Generally the spreading varieties give much higher yields than the erect ones. The seasonal fluctuations have been very great. The variation in Sogatoor was ± 12%. For all spreading varieties the average was 74 ± 15% compared with Sogatoor the yield of which was taken as 100% for comparison. The average yield of erect varieties was only 41 ± 14.4%. The erect varieties do not yield well under our conditions. The great advantage with them is that they can be easily lifted and require less labour. Being early ripeners, they can be sown in areas where the seasons are short. It is interesting to note that the average range of variations due to seasonal conditions is almost the same for all varieties. It is ± 15% for spreading varieties and ± 14.4% for erect ones or about ± 250 lbs.

The following table gives the relative position of the varieties according to their productiveness :—

	Average of ten years' yields expressed in percentages
Spreading varieties :—	
1. Local Sogatoor	.. 100.0 ± 12
2. Carolina	.. 93.7 ± 13
3. Barbados	.. 90.3 ± 11
4. Virginia	.. 83.9 ± 20
5. Transvaal	.. 86.1 ± 17

	Average of ten years' yields expressed in percentages
Spreading varieties :—	
6. Mauritius	87.0 ± 19
7. Big Japan	76.9 ± 16
8. Pondicherry	75.3 ± 18
9. Brazil	73.3 ± 18
Erect varieties :—	
10. Spanish	45.9 ± 18
11. Small Japan	36.8 ± 13

(*N.B.*—Yield for Virginia is the average of 7 years only.)

Yields per acre and their percentage relations for each year are given in the following table :—

GROUNDNUT VARIETAL TESTS.

(1917 to 1926)

No.	Variety	1917		1918		1919	
		lbs.	%	lbs.	%	lbs.	%
1	Sogatoor ..	733	100	1,675	100	1,361	100
2	Carolina ..	724	98.7	1,404	83.8	1,225	90.7
3	Barbados ..	678	92.4	1,419	84.7	1,235	90.7
4	Virginia						
5	Transvaal ..	628	85.6	1,166	69.6	1,089	80.0
6	Mauritius ..	730	99.5	1,017	60.7	1,149	83.7
7	Big Japan	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	Pondicherry ..	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	Brazil ..	499	68.0	1,232	73.5	817	59.7
10	Spanish ..	151	20.6	748	44.6	655	46.6
11	Small Japan ..	127	17.3	699	41.1	726	53.3

No.	Variety	1920		1921		1922	
		lbs.	%	lbs.	%	lbs.	%
1	Sogatoor ..	1,058	100	[illegible]	[illegible]	[illegible]	[illegible]
2	Carolina ..	1,322	124.9	2,295	83.8	954	73.4
3	Barbados ..	1,265	119.5	2,316	87.9	920	70.8
4	Virginia ..	1,403	132.6	1,440	54.6	989	76.1
5	Transvaal ..	1,389	130.4	2,050	77.8	839	64.5
6	Mauritius ..	1,403	132.6	2,253	85.0	920	70.8
7	Big Japan ..	1,150	108.6	2,233	88.6	1,150	88.5
8	Pondicherry ..	1,104	104.3	1,050	39.8	1,150	88.5
9	Brazil ..	1,219	115.2	1,333	50.6	1,104	84.9
10	Spanish ..	759	71.7	681	25.8	759	58.4
11	Small Japan ..	429	40.5	600	22.7	429	33.0

No.	Variety	1923		1924		1925	
		lbs.	%	lbs.	%	lbs.	%
1	Sogatoor ..	2,062	100	1,756	100	2,400	100
2	Carolina ..	1,700	82.4	1,713	97.5	2,450	102.0
3	Barbados ..	1,450	70.3	1,594	90.7	2,483	103.4
4	Virginia ..	1,450	70.3	1,408	80.1	2,567	106.9
5	Transvaal ..	1,450	70.3	1,768	100.6	2,533	105.5
6	Mauritius ..	1,375	66.6	1,558	88.7	2,367	98.6
7	Big Japan ..	1,037	45.4	1,187	67.5	1,616	67.3
8	Pondicherry ..	975	47.2	1,204	68.5	2,100	87.5
9	Brazil ..	1,050	50.9	1,280	72.8	2,016	84.0
10	Spanish ..	1,262	61.2	1,206	68.6	1,000	41.6
11	Small Japan ..	1,137	55.1	912	51.9	716	29.8

No.	Variety	1926		Average of ten years		
		lbs.	%	lbs.	Percentage	
1	Sogatoor ..	1,730	100	1,670.7	100 ±12.1	
2	Carolina ..	1,730	100	1,543.9	93.7±13.2	
3	Barbados ..	1,611	93.1	1,497.1	90.3±11.1	
4	Virginia ..	1,166	67.3	1,489.0	83.9±20.3	
5	Transvaal ..	1,333	77.0	1,423.6	86.1±16.7	For Sp. var. 74±15
6	Mauritius ..	1,417	81.9	1,422.0	87.0±19.0	
7	Big Japan ..	1,266	73.1	1,254.5	76.9±16.0	
8	Pondicherry ..	1,266	73.1	1,237.4	75.3±18.5	
9	Brazil ..	1,266	73.1	1,181	73.3±18.0	
10	Spanish ..	365	21.0	756.6	45.9±18.0	For Er. var. 41.3±14.4
11	Small Japan ..	399	23.0	617.7	36.8±13.2	
	Average for all varieties			1,281.2	77.7±20.0	

The names given to varieties do not indicate that they are all different. They only represent their source or the country from which they were introduced. Some of them vary in their productive capacity. It is possible to group them under the following heads :-

Spreading varieties :— Productiveness

Group I.

1. Carolina .. .. 93.7±13%
2. Barbados .. .. 90.3±11%

Group II.

1. Transvaal .. .. 86.1±17%
2. Mauritius .. .. 87.0±19%

Spreading varieties :—	Productiveness
Group III.	
1. Pondicherry	75.3 ± 18%
2. Brazil	73.3 ± 18%
3. Local Sogatoor	100.0 ± 12%
Group IV.	
1. Big Japan	76.9 ± 19%
Group V.	
1. Virginia	86.1 ± 17%
Erect varieties :—	
Group VI.	
1. Spanish	45.9 ± 18%
2. Small Japan	36.8 ± 13%
Group VII.	
1. Local Mysore	

Carolina, Barbados, Virginia, Mauritius and Transvaal have been distributed in the State to some extent. A variety called "Bunch Virginia" was introduced from Northern India; but it was found to be the usual spreading variety.

Through the courtesy of the Department of Agriculture of the United States of America, seven of their best varieties of groundnuts were secured in 1927. The samples of pods and seeds were very good, especially those of Valencia and Tennessee. On sowing, most of them were found to be erect varieties. Except Virginia bunch and Virginia runner, all the rest have pale green leaves, and excepting these two, all the rest were badly attacked by the *tikka* or leaf spot disease (*Cercospora personata*). They seem to be highly susceptible to this disease. From this experience, as also from many other trials with other crops, it is now quite clear that the future development of our crop plants depends upon the evolution of better plants *locally* by judicious selection and breeding. The exotics no doubt furnish excellent material for building up new types of plants.

Spacing Experiments.

In the varietal experiments it was found that the erect types were giving only about half the yield of the spreading ones. I wanted to see whether by closer planting we could increase the yield. While testing the erect varieties, I thought of observing the effect of closer

sowings on spreading varieties as well, and the spacing experiments were laid out in 1921. In all these experiments, Sogatoor sown in lines 12 inches apart has been taken as the standard for comparison.

In one set of experiments Sogatoor was sown at various distances—distances being the same both between rows and in the rows. Figures given in the following table show that closer sowing gives a very much greater yield than wider sowings. Sowing three inches apart only, increases the seed rate without giving a proportionate increase in the yield, and groundnut seed is costly.

TABLE I.

VARIETY—SOGATOOR.

In all the years the yields are averages of five plots in lbs. per acre.

Spacing	1921	1922	1923	1924	1925	1926	Average
3″	2,673.2 114.3%	1,478.8 105.7%	..	..	..	..	110 %
6″	2,458.3 105.1%	1,640.2 117.2%	1,032.3 145.4%	2,097.0 160.5%	2,613.0 142.0%	1,217.0 118.1%	131.3%
9″	2,592.6 110.9%	1,371.3 98.0%	935.5 131.8%	1,806.0 138.2%	2,242.0 121.9%	1,284.0 125.0%	120.9%
12″	2,337.4 100.0%	1,398.1 100.0%	709.7 100.0%	1,306.0 100.0%	1,839.0 100.0%	1,030.0 100.0%	100.0%
18″	1,853.8 79.3%	941.0 67.3%	..	..	..	..	67.3%

The following table gives the yields of Spanish and Mauritius varieties sown at various distances. Closer sowing has given better results in both the cases.

TABLE II.

Year 1921

In each year the yields are averages of five plots in lbs. per acre.

Spacing	Spanish	Mauritius
6″	1,613.5 116.6%	2,120.6 153.3%
9″	1,830.9 132.3%	1,659.6 120.0%
12″	1,152.5 83.3%	1,383.0 100.0%
18″	898.8 64.9%	1,290.8 93.3%

For the main set of experiments all the varieties were sown in rows 6″ and 12″ apart. The distance between seed to seed in the row was about 6″ and all the varieties were repeated three times as in previous experiments. Table III gives the yields in lbs. per acre, Table IV gives the yields in percentages and Table V gives the totals of the averages and differences due to the differences in sowing distances.

TABLE III.

Spacing experiments in groundnuts 6″ & 12″ apart rows.

Yield of pods in lbs. per acre.

No.	Variety	1921		1922		1923	
		12″	6″	12″	6″	12	6″
1	Sogatoor ..	2,633	3,083	1,299	1,500	1,951	2,227
2	Carolina ..	2,203	2,916	945	1,533	1,503	1,714
3	Barbados ..	2,316	2,708	920	1,216	1,303	1,701
4	Transvaal ..	2,050	2,625	839	1,600	1,628	2,932
5	Mauritius ..	2,293	2,833	920	1,216	1,497	1,773
6	Virginia ..	1,440	3,020	989	1,600	1,475	1,847
7	Brazil ..	1,333	2,283	1,104	1,433	1,483	1,589
8	Pondicherry ..	1,550	2,413	1,150	1,600	1,107	1,452
9	Big Japan ..	1,875	2,333	1,150	1,435	1,277	1,630
10	Small Japan ..	446	600	429	716	1,064	1,603
11	Spanish ..	..	..	759	933	1,312	753
	Averages ..	1,814.2	2,481.4	955.0	1,343.6	1,418.1	1,756.4

No.	Variety	1924		1925		1926	
		12″	6″	12″	6″	12″	6″
1	Sogatoor ..	1,524	1,988	2,400	3,200	1,730	2,083
2	Carolina ..	1,459	1,966	2,450	3,133	1,722	1,972
3	Barbados ..	1,326	1,863	2,483	2,833	1,611	2,250
4	Transvaal ..	1,574	1,963	2,533	2,733	1,333	1,750
5	Mauritius ..	1,390	1,726	2,367	2,600	1,417	1,972
6	Virginia ..	1,098	1,718	2,567	3,200	1,167	1,555
7	Brazil ..	1,092	1,468	2,016	2,713	1,477	1,630
8	Pondicherry ..	1,085	1,323	2,100	3,153	1,477	1,703
9	Big Japan ..	1,044	1,331	1,616	2,346	1,477	1,553
10	Small Japan ..	736	1,088	716	1,301	465	663
11	Spanish ..	1,021	1,389	1,000	1,540	542	1,553
	Averages ..	1,213.5	1,620.2	2,022.5	2,623.0	1,310.7	1,698.5

No.	Variety	Average for six years	
		12″	6″
1	Sogatoor	1,922.8	2,363.5
2	Carolina	1,714.1	2,205.6
3	Barbados	1,659.8	2,091.1
4	Transvaal	1,659.5	2,117.1
5	Mauritius	1,647.3	2,020.8
6	Virginia	1,456.0	2,156.6
7	Brazil	1,417.5	1,852.6
8	Pondicherry	1,411.5	1,940.6
9	Big Japan	1,406.5	1,771.0
10	Small Japan	642.6	995.0
11	Spanish	926.8	1,433.6
	Averages ..	1,442.2	1,904.6

Table IV.

Spacing experiments in groundnut—6″ & 12″ apart rows.

Figures are in % yields having local Sogatoor sown 12″ apart as the standard 100%.

No.	Variety	1921		1922		1923	
		12″	6″	12″	6″	12″	6″
1	Sogatoor ..	100.0	117.0	100.0	115.4	100.0	114.1
2	Carolina ..	84.1	110.7	72.7	118.0	77.0	87.8
3	Barbados ..	87.9	102.8	70.8	93.6	66.7	87.2
4	Transvaal ..	77.8	99.9	64.4	123.9	83.4	104.1
5	Mauritius ..	87.1	107.6	70.8	93.6	76.7	91.1
6	Virginia ..	54.7	114.7	76.0	123.9	75.6	94.6
7	Brazil ..	50.6	86.7	85.0	110.3	76.6	81.4
8	Pondicherry ..	58.8	91.7	88.5	123.9	56.7	74.4
9	Big Japan ..	71.2	88.6	88.5	110.3	65.4	83.5
10	Small Japan ..	17.0	22.7	33.0	55.1	54.5	83.5
11	Spanish ..	..	..	50.7	71.9	67.3	89.8
	Averages ..	68.9	94.2	72.7	103.6	64.5	90.4

No.	Variety	1924		1925		1926	
		12″	6″	12″	6″	12″	6″
1	Sogatoor ..	100.0	130.3	100.0	137.5	100.0	120.4
2	Carolina ..	95.7	129.0	102.0	130.5	99.5	110.3
3	Barbados ..	87.0	122.2	103.4	118.0	93.1	130.0
4	Transvaal ..	103.2	128.8	105.5	113.8	77.0	101.1
5	Mauritius ..	86.6	113.2	98.6	108.3	81.9	113.9
6	Virginia ..	72.0	112.7	106.9	133.3	67.4	89.8
7	Brazil ..	71.6	96.3	84.0	113.0	85.3	94.2
8	Pondicherry ..	71.6	86.8	87.5	131.3	85.3	98.4
9	Big Japan ..	68.5	87.3	67.4	97.7	85.3	89.2
10	Small Japan ..	41.7	71.3	21.8	54.2	26.8	38.3
11	Spanish	67.0	91.1	41.6	64.1	31.3	89.2
	Averages ..	78.5	106.2	83.5	109.2	75.7	97.7

No.	Variety	Average for six years	
		12″	6″
1	Sogatoor	100.0	122.45
2	Carolina	88.5	114.3
3	Barbados	85.0	108.9
4	Transvaal	85.2	111.9
5	Mauritius	83.6	104.6
6	Virginia	75.4	111.5
7	Brazil	75.1	96.9
8	Pondicherry	74.6	101.0
9	Big Japan	74.4	92.7
10	Small Japan	32.4	54.2
11	Spanish	57.5	81.2
	Averages ..	73.9	99.7

TABLE V.

Groundnut spacing experiments. Six years' averages.

Yield of pods	12″ lbs. per acre	6″ lbs. per acre	12″ percentage	6″ percentage	Difference between 12″ & 6″
Sogatoor ..	1,922.8	2,363.5	100.0	122.5	22.5
Carolina ..	1,714.1	2,205.6	88.5	114.3	25.8
Barbados ..	1,659.8	2,011.8	85.0	108.9	23.9
Transvaal ..	1,659.5	2,117.1	85.2	111.9	26.7
Mauritius ..	1,647.3	2,020.8	83.6	104.6	21.0
Virginia ..	1,456.0	2,156.3	75.4	111.5	36.1
Brazil ..	1,417.5	1,852.6	75.1	96.9	21.8
Pondicherry ..	1,411.5	1,940.6	74.6	101.0	26.4
Big Japan ..	1,403.5	1,771.0	74.4	92.7	18.3
Average for Spreading Varieties ..	1,588.6	2,048.8	82.4	107.1	24.7
Small Japan ..	642.6	995.0	32.4	54.2	21.8
Spanish ..	926.8	1,433.6	57.5	81.2	23.7
Average for Erect Varieties ..	784.7	1,214.3	44.9	67.7	22.8
TOTAL AVERAGE ..	1,442.4	1,897.0	75.6	99.9	24.3

In these experiments also, Sogatoor sown in 12″ rows was taken as the standard for comparison. It is seen that the increase brought about by closer sowing is about 24.7% for spreading varieties and 22.8% for erect varieties. One can safely take about 21% as the increase due to closer sowing : by a simple change in the method of sowing one can so vastly increase his income from the same extent of land. Even if 20% increase is taken for calculations, it represents an yield from nearly 200,000 acres in Mysore, when the extent of cultivation has reached its maximum area of 1,000,000 acres representing in money value Rs. 8,400,000 or nearly £600,000 per year.

By the introduction and extension of groundnut cultivation, and by effecting improvements in the methods of cultivation and manuring, the earning capacity of each head of population in Mysore can be increased by Rs. 9 to 10. It has been calculated that the present average earning capacity is only Rs. 30 per head. Manufacturing industries are responsible for about Rs. 10 per head of population (Sir M. Visvesvaraya's Speeches, 1910 17, Vol. I, page 82). From these figures it can be seen that a proper development of groundnut cultivation will enrich the Mysorean as much as if not

more than all the existing industries in the State. If crushing mills are set up to utilize the whole produce, the benefits would be very much greater. The availability of a large quantity of rich oil-cake in the country would naturally induce the cultivators to use more cake for manuring, to reap better harvests, and to feed their cattle with more concentrates. The results of these activities would be the building up of a prosperous countryside. I have indicated sufficiently the importance of this plant industry to the State, and it now remains to be seen how far this industry would develop in future.

In regard to spacing experiments, the United States Department of Agriculture has also carried on a series of experiments between 1917 and 1919 in co-operation with the South Carolina Agricultural Experiment Station. The results have been published in the Department Bulletin No. 1478, published in March 1927. Their results also agree with mine. They also advocate closer sowing now.

In order to allow sufficient passage for the mule to pass, seeds were sown in rows of four feet and the spacing in the rows was from 4 to 15 inches. The experiments were conducted at Pee Dee Station, Florence, D.C. The soil was "Orangeburg sandy loam" with yellow clay subsoil. 100 lbs. per acre of ground limestone was applied to the land. And 800 lbs. of a fertilizer containing 2% nitrogen, 8% phosphoric acid and 3% of potash was applied and ploughed in. Improved Spanish variety was used for sowing. These experiments indicate that closer sowings increase yields of peanuts and hay.

The following table gives the average yields in 1917, 1918 and 1919 of peanuts in rows $2\frac{1}{2}$ and 3 feet apart in which the seed was spaced at various intervals.

PEE DEE STATION, FLORENCE (U. S. A.).

Row and plot	Spacing in rows.	Yield of peanuts per acre	Yield of hay per acre
Rows $2\frac{1}{2}$ ft. apart— Plot No.	inches	pounds	pounds
1	3	850.00	2,023.33
2	6	713.33	2,056.67
3	9	590.00	1,610.00
4	12	573.33	1,693.33
5	15	595.00	1,560.00
Rows 3 ft. apart—			
6	3	763.33	1,830.00
7	6	653.33	1,656.67
8	9	653.33	1,700.00
9	12	570.00	1,606.67
10	15	476.67	1,420.00

So far as the development of the individual plant is concerned, it requires about a square yard of space for full growth and sometimes a plant may produce even 100 or 150 nuts. But to get the biggest yield per acre of land, seeds have to be sown about 6″ apart or a square yard should have about 36 plants. Large number of flowers produced near the base of the plants, set and produce pods. The optimum distance varies to some extent with soils and climates, and that could be easily found out by trials.

Lime and Water Requirements.

It is generally believed that groundnut requires plenty of lime and without lime, there would be a large number of empty pods. Large numbers of calcium oxalate crystals are found in the leaves. The analysis of the plant shows that it contains a large quantity of lime in the stem. In the seed itself there is not much of lime.

	Percentage of lime.
Stem	2.03
Shell	0.81
Kernel	0.13
The whole plant	3.75

The following experiments were conducted in 1926 and 1927 to find out the effect of the absence of lime in the soils on the formation of pods.

White (lime-free) glass sand was used for filling the pots. The water-holding capacity of the soil was 26.43%.

Weight of pot+stone pieces for drainage was 9 kilos.

do +sand 25 kilos.

On an average each pot contained 16 kilos of sand.

In the beginning each pot was watered with 1 kilo of water and later on the weight of the pot was kept at a constant weight of 27 kilos by adding water once, daily.

The following amount of nutrient salts were dissolved in 5 litres of water and sand in each pot was mixed well with 500 c.c. of the solution. This solution was kindly suggested to me by Dr. B. Narasimha Iyengar, Ph.D. (Gottingen), the Agricultural Chemist of the Department.

0.5 gram N in the form of KNO_3
1.0 ,, MgO ,, $MgSO_4$
0.5 ,, Na_2O ,, Na_2SO_4 } given only as NaCl
0.5 ,, Na_2O ,, NaCl }
5.0 ,, P_2O_5 ,, K_2HPO_4
2.0 ,, K_2O ,, K_2SO_4
1.0 ,, K_2O ,, KCl
0.25 ,, $FeCl_6$

In all eight pots were used for the experiment. Four pots were given small doses of ground lime ($CaCO_3$) at the rate of 10 grams of CaO for each pot. And four pots had no lime. Two seeds of Spanish were sown in each pot on 23rd June 1926. Water was added every now and then to bring up the weight of the pot to 27 kilograms. The germination and growth of plants was normal in all pots. The general appearance of the plants was always better in the limed pots. One plant died in each series. The plants were harvested on 6th Oct. 1926 and the period of growth was 105 days.

The following table gives the weights of vines and nuts :—

Weight of plants.—	Plants from limed pots		Plants from unlimed pots
No.	grams	No.	grams
1. ..	.. 25.7	1. ..	.. 25.0
2. ..	.. 23.4	2. ..	.. 23.0
3. ..	.. 20.4	3. ..	.. 23.5
4. ..	.. 14.5	4. ..	.. 14.0
5. ..	.. 17.5	5. ..	.. 19.6
6. ..	.. 14.9	6. ..	.. 15.0
7. ..	.. 12.7	7. ..	.. 14.6
	129.1		134.7
	80 nuts= 74.6		50 nuts= 51.6

There was not much of a difference so far as the green weight of the plants was concerned. By adding lime, there was a large increase in the number of nuts and the total weight of nuts. On an average, each limed plant produced 11.4 nuts weighing 9.1 grams, whereas unlimed plants produced 7.1 nuts weighing 7.3 grams.

Absence of lime did not produce any hollow pods. On the other hand, the individual weight of each pod in unlimed pots was slightly more than the weight of pods in limed pots. Weight of a

pod in unlimed pot was 1.0 gram, whereas the weight of a pod in limed pot was about 0.8 gram

However poor the soils may be in lime. I am of opinion that the soils under field conditions will have some lime at least. Especially when the field bears alternate crops of ragi and groundnut the field is bound to have some lime. It may be that lime content is very poor and that the yields may be greatly increased by the addition of lime. But the hollowness of pods cannot be ascribed to the lime-deficiency in the soil and causes should be sought for somewhere else.

To test the results obtained in the last experiment the following experiment was planned and carried out in 1927. Eight pits were dug in the ground. They were 2 yards square or 4 square yards in surface area and one yard deep. Every pit was filled with a different type of soil and consolidated. Seeds of H.G. No. 1 were sown for observation in July and harvested in November. The physical analysis of the soils were kindly made by Dr. B. N. Iyengar and Mr. Ellappa Chetty of this Department. The following table gives the analysis of seven typical soils :—

MECHANICAL ANALYSIS OF SOILS.

(ALTERBERG'S METHOD)

	Measurement of soil particles	Sand	Dry land Soil	Garden Soil	Red Soil	Wet land Soil	Tank Silt	Clay
	m.m.	%	%	%	%	%	%	%
Fine gravel ..	2–1	12.14	5.84	5.68	5.91	3.00	2.05	2.98
Coarse sand ..	1–0.5	15.46	9.50	8.66	4.89	4.06	2.71	5.18
Fine and med. sand.	.5–.1	59.38	64.04	63.88	38.46	40.79	27.31	28.04
Very fine sand ..	.1–.05	2.10	5.26	4.95	9.03	8.89	11.24	5.03
		89.08	84.64	83.17	58.29	56.74	43.31	41.23
Silt ..	.05–.005	2.08	5.68	5.78	7.97	13.77	17.90	10.99
Clay ..	.005 & below	7.25	7.37	8.03	23.53	20.77	27.00	37.7
Moisture and loss on ignition ..		1.59	2.31	3.02	10.21	8.72	11 79	10.06

Results of the tests were :—

1. In pure stream sand the plants made a good growth and produced well-filled healthy nuts. There were no hollow pods.

2. In the dry land soil there was a better growth. Healthy nuts were formed and there were no hollow pods.

3. In red soil the growth was poorest. Very few nuts were formed ; but there were no hollow pods.

4. In garden soil the plants were healthy and formed good nuts. There were no hollow pods.

5. In wet land sugarcane field soil, there were many big healthy nuts. There were no hollow pods. But the appearance of the pods was not quite good. Many clay particles got stuck to the shell and the pods required a little washing and drying.

6. In tank silt, the plants were very healthy and they produced many pods. It was fairly easy to harvest also. There were no hollow pods and the appearance was slightly better than that of pods from wet land soil.

7. In blue clay, the growth of the plants was very good. As the clay retains moisture when the other plots were wilting sometimes, the clay plot used to be green and fresh. It was difficult to dig and take out the pods and free them from clinging particles of clay. There were no hollow pods.

In no case were there hollow pods. The differences were only in the growth of the plant, the number of pods produced and their appearance. As the appearance of a consignment greatly influences the price on the market, care is required to select lands for growing groundnut. Clays and wet land soils are not desirable for producing high grade nuts. Very fine pods can be secured from sandy loams and red soils. But such soils require more cultivation and better manuring.

The following table gives the weights of 100 pods and seeds shelled from them as produced on the different kinds of soils :—

No.	Soils.	Total weight of 100 pods.	Weight of seeds from 100 pods.	No. of seeds.	Weight of 100 seeds.
		grams	grams		grams
1.	Sand ..	166	126	220	57.3
2.	Dry land soil ..	208	153	280	54.6
3.	Sandy-red loam	178	132	230	57.3
4.	Wet land soil clay loam ..	171	123	240	51.3
5.	Garden soil sandy loam ..	..	..	..	..
6.	Tank silt ..	177	136	260	52.3
7.	Blue clay ..	179	137	220	62.3

In clay there is more plant food and naturally the seeds produced on it are the heaviest. On the whole a good sandy loam seems to be the best soil for groundnut production in Mysore. A liberal application of manures may greatly help the ryot to harvest bigger crops.

In none of these soils was there any hollow pod. From the various observations I have made, I am persuaded to believe that hollow pods are formed under the following conditions:—

1. Imperfect fertilization of flowers is the main cause in several cases. Virginia mostly and sometimes Big Japan produce hollow pods, probably for this reason. Many hybrids have produced hollow pods. H.G. 1 also forms hollow pods for the same reason. By careful selection such plants can be eliminated. In 1926 in one sample of H.G. 1, there were nearly 80% plants producing such pods. By selection they have been eliminated to a great extent. In 1927 there were hardly 20% of the plants producing hollow pods and now there are none.

2. A species of *Fusarium* has been found to attack the pods in various stages of development. When the embryo is attacked the development of the seed stops, but the pod grows to its normal size. In such cases hollow pods are produced. This disease has been observed recently and no remedial measures have been discovered. Treating the seed with corrosive sublimate or with formalin will be tried. Selection of seeds before sowing seems to be a good method to check this fungus. Nine out of twenty rejected seeds showed the growth of this fungus in the germination box. But in the selected seeds only 6% were attacked by it.

3. Deficiency of rainfall after the pods have begun to develop produces a large number of hollow pods. During some droughts nearly a third of the pods produced were empty.

Water Requirement.

Groundnut plant responds very well to water. With more water more growth is obtained and without water, the plant gets stunted and fails to develop pods.

In the previous experiments, the quantity of water given on each occasion and the daily rainfall were recorded. They give a rough idea as to the water requirement of the crop. There were two plants in each pot and the area available for one plant was 39.3 sq. inches. The rainfall during the period was 15.65 inches.

The quantity of water used by the 14 plants in the limed and unlimed series was nearly the same, but the green weight of organic matter produced was different.

	Water given +Rain	Green weight Organic Matter
Limed Pots	211,282 c.c.	203.7 grams
Unlimed Pots	212,502 c.c.	186.3 ,,

On an average, each plant received by rain 7,354 c.c. of water, and the quantity of water given was 11,768 c.c.

The total quantity of water used by one plant was about 19,121 c.c., equivalent to 29.6″ of rainfall.

Some crops have been grown even with 10″ of rainfall, but to get a full development of the plants at least about 29 inches of rainfall seems to be necessary. During the first 45 days, the average consumption of water per plant was 237 c.c. per day. The next 23 days formed the period of great activity. The plant was flowering and setting seeds. It was increasing in bulk also and the transpiration was the greatest during this period. Between the 6th and 8th of September, the transpiration was greatest, reaching 818 c.c. of water per day. Generally, during this period the daily transpiration was about 408 c.c. During the last 27 days the transpiration of water per day lessened to 356 c.c. per day. The critical period seems to be between the 6th and the 10th week. Five weeks after sowing, the plant begins to flower. Many branches are produced by the 7th week. The largest number of flowers develop and set during the 7th and 8th week. And the pods develop and ripen in 50 days after they get into the land. That is, in about 60 days after the flower is fertilized the pod is fully ripe.

It will be seen, therefore, that if there is a low rainfall or drought during the 6th and 12th week, the resulting crop will be poor. Heavy rains either before or after this period do not seem to influence the yield very much. The following Table gives the rainfall and the average yields per acre from 1917 to 1926.

The biggest yield of 2,022 lbs. per acre was obtained in 1925 when the rainfall during the season was only 14.92 inches, and the lowest yield of 955 lbs. per acre was during 1922 when the rainfall was 34.29 inches. During this period of heavy rainfall 23.82 inches fell in October and November, whereas in 1925 during the same

period only 2.68 inches of rainfall occurred. A study of the Table shows that rainfall during October, November and December does not influence the yield. On the other hand, late rains stimulate heavy vegetative growth and the setting of a very large number of flowers. In December, dry weather sets in, the top layer of soil gets dry, and a large number of hollow pods occur owing to the presence of immature pods.

The following Table shows how the yields have been influenced by rainfall :—

Year	Yield lbs.	Rainfall inches	No. of days
1925	2,022	14.92	44
1921	1,875	27.60	77
1918	1,675	22.25	38
1923	1,481	15.25	42
1919	1,361	31.92	59
1926	1,310	16.34	21
1924	1,213	20.30	42
1920	1,058	16.85	43
1922	955	34.29	69
1917	732	28.08	61

Very low rainfall in July, as in 1924, seriously affected germination and the normal growth of the plants. On the other hand, heavy rains caused rotting of many seeds and young seedlings. Heavy rains in August and September seriously interfered with the fertilization of flowers. Excessive moisture in the folds of the petals between 4 A.M. and 9 A.M. caused the bursting of pollen grains and prevented fertilization. The following Table gives the conditions during the two typical years :—

Month	1925 Pods 2,022 lbs. per acre		1922 Pods 955 lbs. per acre	
	Rain inches	Days	Rain inches	Days
July ..	2.56	9	3.92	16
August ..	4.67	16	4.02	15
September	5.01	9	3.43	11
October ..	1.14	4	16.31	15
November	1.54	6	7.51	12
TOTAL ..	14.92	44	34.29	69

Rainfall during July and August was very nearly the same during both the years, being 7.23 and 7.04 inches respectively. But in September there was 5.01 inches of rain in 1925, and 3.43 inches in 1922. During the last two months there were very heavy rains in 1922.

The year 1925 seems to be a typical year showing the minimum requirement of rainfall for a successful crop on dry lands. A moist seed bed is required for good germination and sufficient moisture is necessary for the plants to make a growth in the first month. During the second month about 5 inches of rain are necessary to help the plants to grow and keep the surface soil moist to help the gynophores to enter the soil.

In the third month a great deal of water is required. At this period there is an excessive transpiration and the pods are developing within the soil. In the last two months just sufficient moisture is required to keep the upper layers of soil moist, otherwise the pods do not develop. When the soil is once soaked and the sub-soil is stored with water and frequent rains during the rest of the period keep the soil moist, groundnut can be successfully grown. Either more, or less rain reduces the yield. The conservation of moisture and drainage of the fields during heavy showers are two important factors in the production of groundnuts.

It is interesting to note the relation between excessive transpiration and heavy rainfalls. Every time when there was a period of excessive transpiration, it was followed by heavy rains. The period of very high transpiration was followed by a period of heavy rains ; and the two days of the highest transpiration were followed by a heavy downpour of 3.03 inches in one day. During cloudy days and slight drizzles, the transpiration was the least. The amount of water transpired was greatest during September when the plants were in their full vigour. If there is not sufficient water in the soil to withstand the heavy call on it during that period, the plants would naturally get a set-back and often begin to wilt. Care must be taken to store the sub-soil very well with moisture by a judicious system of cultivation.

(*To be continued.*)

The Trunk-Splitting Disease of Areca Palms.

BY

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During recent years a disease that has so far not been reported upon in the areca or any other palm anywhere has been making its appearance in the rainy districts or the *Malnad* of Mysore and in the adjoining portions of North and South Kanara. Heretofore the only serious disease of the areca palm in these parts has been the *Koleroga* of the nuts caused by *Phytophthora arecae*. but for the last six years a rather serious disease involving the splitting of the trunk from the top portions has been noticed. and it threatens to ruin the arecanut industry. The earliest symptom of the disease is the formation of a longitudinal crack on one face of the trunk, usually that towards the west or south-west. (See Plate.) The exposed portions of the trunk in this crack are of a black colour apparently consisting of the protective fibro-vascular bundles covering up the open longitudinal wound. The wound begins about three or four feet below the lowest bunch and may extend twenty or twenty-five feet downwards. In bad cases almost the whole trunk may be involved. The wound does not extend very far laterally nor is it usually very deep. The tissues attacked may be from a half to one inch in thickness. Ultimately a greater amount of the tissues becomes involved. The disease has not been noticed on palms below 8 or 10 years of age. Palms of almost any age above this may be seen affected. The disease is more virulent in the outskirts of the garden and in the more exposed portions than in the interior. In some badly affected patches it is very rare to find even one palm with a whole trunk. Such patches occur where the palms receive the full force of the western sun. Affected trees may continue to bear a normal crop for a number of years. But since the trunk gets gradually eaten out it becomes weak, and the operations of spraying, *kotte*-tying and harvesting of the nuts are rendered risky. Very often when these affected trees are pulled by the long bamboo hook used in these operations so as to bring the bunches within reach, the trunks break away at the weakest point. The wind completes the damage. During the heavy gales of the south-west monsoon, the affected palms may be seen

Top portion of trunk of areca palm affected by Trunk-Splitting Disease. Note the crack from about the middle downwards. The top portion of the plate which is about 4 ft. below the crown shows the initial stages of cracking.

split in all sorts of ways. Since whole trees are lost the effects of this disease are very serious. No actual count has been made of the number of trees lost in an acre, but the loss may be estimated to vary from ten to thirty or forty.

The exact cause of the disease has baffled the garden-owners A fair proportion of these gardens has been sprayed for the past fifteen years with a strong solution (2%) of Bordeaux mixture and some adhesive (resin and soda or casein and lime). The very first trial spraying was conducted in the year 1909, and since then spraying has been on the increase every year. Of late, the number of acres sprayed has shown a tendency to fall off and this coincides with the period when this new disease manifested itself. The persons who have been spraying attribute the cause of the disease to the injurious effects of the Bordeaux mixture and try to curtail the spraying to the minimum. Those who use the mixture with the resin adhesive blame the resin saying that it makes the mixture stick fast and allows the injurious chemicals gradually to penetrate the trunk. Many garden owners believe that the new disease is due to the spray mixture. They think that during the spraying the excess mixture runs down the trunk, collects up and dries in a longitudinal line and gradually penetrating into the trunk destroys the tissues. Were this so, it is hard to believe that the mixture always runs down the trunk on the same face, in view of the fact that the decayed patch is invariably on the western or south-western side. There are some who believe that this adverse result is due to the practice of using the straight jet for spraying, which involves a great wastage of the mixture. In the early days of the spraying the spreader nozzle was generally used, the jet being used only on tall trees too high to be reached by the other nozzle. The spraying work can be done about three to four times as fast with the jet as with the spreader nozzle, and nothing would now induce the climber to go back to the spreader nozzle.

As regards the injurious effects of Bordeaux mixture, Dr. L. C. Coleman in his "Diseases of the Areca Palm : I. Koleroga"—Mycol. Series Bul. No. II. Dept. Agri. Mys. State. 1920, says "The extensive experiments that have been carried out on the potato, the grape-vine, etc., however, make this very improbable. According to some experiments the spraying has, in fact, a directly beneficial effect,

leaving the question of disease out of consideration altogether. The only noteworthy injuries to fruits or plants I am aware of are the spots produced on the fruits of certain varieties of apples, and the burning of the fruit and leaves of the peach, etc. At the beginning it may be said that in all the thousands of nuts sprayed this year not the slightest sign of any such injury was to be seen, so we are safe in saying that the Bordeaux mixture has no injurious effect upon the nuts." Although it is true that some spray mixtures have proved to be injurious at times and under certain conditions, nothing of the kind similar to that now ascribed to the Bordeaux mixture has been noticed in any part of the world.

The disease is by no means confined to gardens where spraying has been done. It occurs to an equal, if not greater, extent in gardens which have never been sprayed. A similar appearance has been noticed even in the *Maidan* parts where spraying for arecanut has not become necessary. The affected portion is always on the western or south-western face of the trunk. Many a garden-owner who was enthusiastic in asserting that he had seen trees being affected on other sides except these two has been convinced of the incorrectness of his impressions by another visit to his garden. This fixed position of the affected portion leads one to infer that the cracking might be due to sun-burn. In fact, it is in portions of the garden where there is no protection on the western face that the disease occurs in a severe form as noted previously. That the western sun can be severe in the *Malnad* and that trees split due to the sun-burn are facts known to everybody. Attempts to find out the real cause of the disease show promising results. Fruit-bodies of bracket-fungi (called in Kanarese 'anabes') have been obtained from portions of the trunk close to the longitudinal groove in standing trees. They are of different kinds and some look like those of a Lenzites and some a Daedalea. Fruit-bodies of *Ganoderma lucidum* have been obtained from stumps of areca trees, but these have not been found in the higher regions where the diseased tissues occur, nor on living trees. In the case of the *anabe roga* of arecanuts due to *Ganoderma lucidum*, common in the *Maidan* parts, the roots and basal portion of the trunk rot, the crown becomes yellow and later dies, and there is also an exudation of a gummy juice from the trunk. (See Mys. Agri. Calendar for 1917 and 1929.) The symptoms in this case being different we

have here to deal with a new disease. Microscopic examination of the tissues has revealed the presence of a fungus in them. This fungus is now under culture in the laboratory and attempts will be made to inoculate healthy trees with it and see if it produces the disease. The bracket-fungi have been known to cause decay, but they require wounds for effecting entry into the tissues of the plant, and hence they are called wound parasites. It is possible that the cracks on the areca trunk due to sun-burn afford means of entry for this parasite.

SELECTIONS.

Chloride Manuring for Tobacco.

Although it is uncertain whether or not chlorine is an essential plant nutrient, W. W. Garner and others have shown (*Jour. Agric. Res.*, 40, p. 627) that manuring with chloride has a far-reaching effect on tobacco and may alter the quality of the cured leaf considerably. Field tests were made using chloride and sulphate of potash. Although the plant absorbed potash equally well from both salts, the chlorine ions were taken up much more readily than the sulphate ions, and on light, sandy soils an average increased yield of ten per cent was obtained with applications of 20—30 lbs. of chlorine per acre. The soils used were very deficient in magnesium, an element of particular importance for the tobacco crop, and since an application of potassium chloride was found to increase the magnesium content of the plants, it would seem that the stimulating action of the chlorine was probably due to an increase in the availability of the magnesium. Further, the addition of chloride resulted in an increased water content of the leaf, thus enabling the plant to resist desiccation, protecting it against the type of injury known as 'drought spot,' a fact which adds materially to its commercial value. On the other hand an excess of chlorine induces an abnormally high moisture content of the leaf and is therefore liable to injure its combustibility and keeping qualities. In addition, it interferes with normal carbohydrate metabolism bringing about an accumulation of starch and a thickening of the leaf. These adverse effects may be caused by applications of 40—60 lbs. of chlorine per acre and are most likely to occur on light soils, with limited buffering properties. From the economic point of view the chlorine nutrition of tobacco is of the greatest importance, for upon it, either directly or indirectly, the commercial value of the crop may depend.—*Nature*, No. 3168, Vol. 126, July 19, 1930.

The Biological Control of Insect and Plant Pests.

The practice of biological control owes its origin to the fact that a great many injurious insects and plants are attacked by parasitic and predacious species belonging to the same group and further many plants injurious to agriculture and forestry have also their insect enemies. Then insect pests which are accidentally imported to new countries leaving

their habitual parasites and predators behind, frequently become extremely numerous and cause immense damage, for experience has repeatedly shown they are generally attacked to only a negligible extent by the beneficial species existing in their new homes. Of the 183 worst insect pests existing in North America, almost half have been introduced, mostly from Europe. In former times no regulations existed that were designed to prevent the importation of insect and plant, but as transport was very slow and no means of preserving foodstuffs existed, opportunities for the migration of injurious insects were not really very numerous; but the development of world trade has permitted and fostered cosmopolitan tastes and requirements which in turn further stimulate commerce between the various parts of the globe. The increase in the development of world trade has thus, as a necessary consequence, caused an increase in the rapidity of the dispersion of pests.

A discussion concerning the disadvantages of mechanical control follows. As an instance, in certain parts of the world, the amount of arsenic used during the ordinary treatment against the Codlin Moth in apples is so great that the arsenical residue on the fruit at the time that it is gathered is dangerously large and has to be removed by special processes, so that in view of the cost of and the repeated applications of poisons and similar methods of control, entomologists are now attempting to utilise the parasitic and predacious enemies which attack injurious insects in nature.—*The Malayan Agricultural Journal*, Vol. XVIII, No. 11.

Conditions Most Favourable for Tractor Operation.

Level topography.—Hills interfere seriously with efficient tractor operation, resulting in loss of power, straining of the machine, and breakage.

Well-drained soil, free from fast stones.—Wet spots in crop fields not only make tractor operation difficult because of miring, but the packing of moist soil is considered by many as a serious disadvantage in the use of a tractor. Fast stones make plowing difficult and increase breakage of the tractor and equipment.

Large, long, regular fields reduce the amount of turning and are worked most economically.

A farm large enough to keep the tractor busy at profitable work.—This means a farm large enough to provide field work throughout the season, and, preferably, belt work in addition. The most effective way to reduce the cost of tractor operation is to keep the tractor busy at profitable work. On some farms custom work offers a desirable way of decreasing the

cost per hour of tractor operation when this work does not interfere with more important work in the home farm.

Distribution of horse labour is such that the tractor will displace horses at the busiest season of horse work. If the greatest pressure of horse work comes in plowing and fitting, the tractor will displace more horses than if the greatest pressure of horse work comes in haying and harvesting.

The saving of man labour is even more important than the displacement of horses, and the possibility of increasing the efficiency of labour by using a tractor is a very important consideration.

Capital available for tractor and equipment.—Certain tools are necessary for efficient use of the tractor. The amount of necessary equipment varies with the kind and size of business. In general, the necessary tractor tools will cost nearly as much as the tractor itself.

Whether or not to buy a tractor is an individual problem. The decision should depend largely upon the answer to two questions. The first is, "Will it pay?" If, after a study of the farm and consideration of the experience of others, it appears that the investment in a tractor would be justified, then the second question is to be considered, "Is there any better way to invest this money?" Many farmers not only have a limited amount of capital available for such investment, but frequently have a number of alternative opportunities for investing this money. The question to be settled then is, "Which will pay best?"—*Bulletin No.* 506 *of the Cornell University Agricultural Experiment Station.*

Coffea Excelsa.

A Variety claimed resistant to the attacks of the Coffee Berry Borer and Leaf Disease.

Nearly all the coffee in circulation comes from *Coffea arabica*. In 1927 this species furnished 93% of the world production, or about 1,588,500 tons out of 1,705,000. The greater part of the remainder came from *Coffea robusta*, to which belongs most (about 113,400 tons in 1927 or 7% of the world production) of the Dutch East Indian coffee. A small amount was furnished by other species, among them *Coffea liberica*, which is the only species cultivated in Surinam (3,037 tons in 1927) and is apparently the most important.

Coffea excelsa.—The numerous other species of coffee are of practically no importance and little has been published concerning their cultivation. Recently, however, it has been found that Coffea excelsa

is of some interest. This species was imported into Brazil from Java in 1923 and planted together with other species from Java in an experimental garden near Rio Claro, which is situated 194 km. to the north-west of Sao Paulo, at latitude 122° 30′ S., near the boundary of the tropical zone and at an altitude of 612 metres. In 1918 the night temperatures between June 25 and 27 were unusually low and fell to 7°C below zero. In the experimental gardens at Sao Paulo all the species of Coffea were badly injured and a number of branches killed. Coffea excelsa alone remained entirely undamaged, neither branches, leaves, nor fruits being injured by the frost (3). Mr. Navarro de Andrade, head of the Botanical Service of the "Companhia Paulista", considers that this species is not of importance in the State of Sao Paulo, where for a number of reasons Coffea arabica is preferred : it is only in certain exposed valleys that Coffea excelsa is given preference. In the State of Parana the latter species is however the only one which will grow successfully at a latitude below 24 and an altitude above 600m., where every year more or less severe frosts occur.

Certain specialists in Brazil consider that C. excelsa is more resistant to the attacks of the coffee berry borer (*Stephanoderes hampei*) than are C. arabica and C. robusta.

After the hurricane which devastated so many of the coffee plantations in Porto Rico in 1928 (4) the experiment station drew the attention of planters in the island to Coffea excelsa, showing that it was of special interest in certain conditions and possessed the following advantages :— It is less exacting in its requirements as regards shade trees and can even grow without shade : it is less liable to damage by prolonged drought ; the vigorous development of its root system and its sturdy growth even in poor soil indicate its possible interest for places where the Arabian varieties do not flourish ; its resistance to the leaf miner is important in some districts ; its production is higher than that of other species and as it ripens during the driest months the crop is less exposed to loss through wind and rain ; lastly, its qualities as a beverage are excellent. There are however a certain number of less favourable characteristics to set against its advantages. It is slow in coming into full bearing, it loses much weight during treatment, and the product is of poor appearance, so is less easily marketable at a good price.

C. excelsa is regarded as having a future also in Madagascar (5) though there it is no more resistant to drought than the other species. Its production is good, however ; at the Ivoloina Experiment Station 10-year old plants gave an average yield of 2 kg. An important point in

its favour is its resistance to Hemileia vastatrix. Its market value is still uncertain.

Tisserant (6) gives some details on the wild habit of Coffea excelsa, which is common in the forests along the Oubangui, a tributary of the Congo ; it is a shrub growing in the less dense parts and the borders of forests in dry areas ; it does not appear to thrive on moist soils.—*International Review of Agriculture*, Part I, Year XXI, No. 2.

Rootstock Influence in Fruit Growing.

The fruit grower has always found one of his outstanding difficulties in the variability of his produce. The fact that varieties seldom, if ever, come true from seed, caused in the first instance propagation by seed to be abandoned in favour of a vegetative method which reproduces completely the characteristics of the parent plant. As, however, not all desirable varieties are capable of producing suckers or forming adventitious roots from the stem for layering, it has been found in practice preferable to bud or graft the variety with desirable fruiting qualities on to an independent root system. Thus the great majority of the tree fruits, such as the apple, pear, plum, cherry, peach, citrus fruits and, in some countries the vine, are produced by means of budding or grafting and hence are composite structures made up of two individuals, the scion and the rootstock.

Variability is not, however, entirely eliminated by means of the composite tree. That the rootstock may influence the tree in certain ways has come to be recognized by nursery-men and growers, at any rate, in Western Europe. The rootstock may be a seedling or may be formed by layering some readily rooting variety. There has been a widespread idea that a seedling stock will give the vigour of growth necessary for an orchard tree, while a layered stock is shallow rooting and will produce a small and comparatively early cropping tree. Since the scion variety is in reality a single individual, any difference must be attributed to the influence of the stock, and the recognition of this fact caused studies of the two kinds of fruit tree stocks in common use in Western Europe to be undertaken in England in 1913.

The variability of the seedling stock was recognized by growers as being often reflected in the scion but was regarded as inevitable on account of its origin. It was a common experience for a grower who had stocked his orchard with a single variety in apparently uniform conditions to find the trees developing the most diverse habits of growth and cropping capabilities. To quote an actual case : some Early Victoria

apples, budded on seedling stocks, were selected from the nursery as one-year-olds for their uniformity in size. Twelve years later at Malling the trees range from spreading dwarfs to vigorous upright trees and their cropping is equally varied. The best trees in the group bore at the rate of 51 tons an acre and the worst at the rate of 10 tons. This means that the grower of a mixed lot of trees such as these would at the end of 13 years from planting have harvested about 28 tons of fruit per acre, whereas if he could have standardised his trees to produce at the rate of the best he would nearly have doubled his crop.

The standardisation of seedling stocks, in the first place for the apple, was undertaken by the Research Station at Long Ashton, Bristol. An attempt was made to obtain uniformity by finding typical vigorous seedlings suitable for the production of orchard trees which were also capable of being propagated by vegetative means. This object was achieved in the rootstock now known as Bristol V, which is layered but retains its deep rooting system and gives a large slow-cropping orchard tree.

This orchard rootstock fulfils the grower's requirement of uniformity but from the economic point of view it has lost the seedling stock's advantage of easy and cheap production, and other methods of obtaining uniformity may be desirable. One method suggested is the grading of seedling stocks in the nursery. It is recognised that the nursery practice used in producing a standard tree necessitates a certain amount of selection to obtain the required height of stem, the weaker stocks being eliminated in the process, but this entails waste and again increases the cost of production.

The process of ' bench grafting ', which is much used in the Middle West of the United States, seems to bring about a considerable degree of uniformity in the orchard. The scion is grafted directly on to a portion of the tap-root of a seedling stock and it is now thought that by this means the influence of the stock is eliminated. It has been shown that the root system of the resulting tree is so much influenced by the scion that varieties can be distinguished by their roots alone. This method would seem to be entirely satisfactory if uniformity in the orchard was all that was to be desired and if different climates, soils and purposes had not to be taken into consideration. It is obvious that if the individual characteristics of both the rootstock and the scion can be retained and their interaction understood, a far wider range of possibilities is opened up.

That the stock has a far wider influence than was at first realised has been discovered by the East Malling Research Station, which undertook the study of layered stocks in 1913. The work was begun with the

object of identifying the different vegetatively propagated rootstocks in commercial use. The layered stock which at least should be uniform, was frequently misnamed and not true to type, and considerable confusion arose, because the nursery-men did not know the possibilities of the young trees. Perhaps a variety sold to a grower as being on a "Paradise" or layered stock and therefore suitable for interplanting between his permanent standard trees, turned out to be as slow-growing and wide-spreading as the permanent trees: he had to wait eight or more years longer than he expected for any return on his outlay and in addition his orchard became over-crowded.

The analysis of these stocks at Malling soon showed that the so-called dwarfing stocks consisted of 17 varieties which could be divided into four groups showing striking differences in their influence on the tree.

The following table shows a comparison of the size of trees and the cropping capacity of Lane's Prince Albert worked on a representative of each of the 4 types and grown on good medium loam at East Malling.

TABLE I.

Stock.	Suitable number of trees per acre.	Crop returns per acre (Bushels)	
		Total for first 4 years.	Total for first 7 years.
Dwarf IX	504	106	1,123
Semi-dwarf II	268	34	590
Vigorous I	150	4	302
Very Vigorous XVI	101	..	152

It is seen that the relative order of cropping in early years is the converse of that of vigour and from the space required that the trees on stocks I and XVI develop into fully-sized orchard trees. The results of this work are that (1) the grower can now plant one variety, if he so desires, as permanent trees and fillers, because he knows the relative vigour of the rootstocks, (2) he can be certain of early returns from the dwarf trees, (3) he knows how to space the trees when planting so as to make full use of the ground when the larger trees have come into full bearing, and (4) he can make his provision for tillage operations knowing with considerable accuracy the type and size of machinery which will be suitable. Such a measure of control more than compensates for the extra cost of a layered stock.

Similar trials on different soils with the same variety on the four types of stocks have shown that the rootstock must be selected in relation to soil conditions as well as to the purpose of the tree. It was found that the absolute size of the tree on any given stock differed markedly on different soils, yet in each case the relative vigour and precocity remained the same. Table II shows the behaviour of two very different varieties on the four stocks on different soils.

TABLE II.

Soil type.	Dwarf.	Semi-dwarf.	Vigorous.	Very Vigorous.
		Bush Lanes.		
Medium Loam ..	Moderate.	Good.	Vigorous.	Very vigorous.
Sandy Loam ..	Small.	Moderate.	Vigorous.	Vigorous.
Heavy Clay ..	..	Moderate to poor.	Good.	Vigorous.
Light Sand ..	Very poor.	Poor.	Small.	Moderate.
		Bramleys.		
Medium Loam ..	Good moderate bush.	Vigorous.	Very vigorous.	Too vigorous.
Sandy Loam ..	..	Good.	..	..
Heavy Clay ..	Very small.	Good, Small.	Good.	Vigorous.

It is hoped in time to be able to construct similar tables for all possible combinations of soil and variety.

Another characteristic which appears to be influenced by the rootstock is the time of blossoming. Control of this feature is of value from two points of view: in places liable to late frosts it is advantageous to be able to grow trees on vigorous stocks which cause late blossoming, and in view of the present knowledge of self-sterile and inter-sterile varieties it is obviously useful to be able to ensure that two varieties which are planted together for pollination purposes will be in blossom at the same time.

Fruit quality as expressed in colour and size is another character which is most certainly influenced by rootstock. It has been found that the very dwarfing stock, Malling Type IX, produces pre-eminently fine quality dessert apples which are larger and appear riper than fruit of the same variety picked from other stocks, and are equally good for storing. On the whole, the more vigorous stocks tend to give less colour, the apples appearing green when ripe on the vigorous Type XVI, and the fruit tends to be smaller on vigorous stocks, though size is apt to fluctuate from year to year on the same tree.

It is evident that in the nursery certain apple stocks are far more susceptible to certain diseases and pests, such as canker (*Nectria galligena*), scab (*Venturia inaequalis*), mildew (*Podosphaera leucotricha*), crown gall (*Bacterium tumefaciens*) and leaf scorch than others, and facts are gradually accumulating from orchard experience and direct experiments which show that the varying susceptibility is transmitted to the scion.

Investigations into the nature and effect of pear, plum, peach and cherry stocks have also been carried out at Malling. In each case the commercial stocks were found to lack uniformity, and the first work was directed towards bringing order out of the confusion.

In the case of pears it has been found that certain of the quince stocks in common use show a marked "incompatibility" with certain varieties, which explains many previously unaccountable failures in the orchard. Some quince stocks have been found to induce earlier fruiting than others. It has been possible also to select and propagate vegetatively a series of a pear root-stocks which will give a wide range of performance when grafted with a given variety. There are indications of disease resistant pear stocks and in America pears on certain root-stocks have been found definitely more susceptible to a physiological disease known as "black-end" than others, some often showing 100 per cent. immunity and others 100 per cent. susceptibility.

In the work with plum stocks for plums and peaches striking evidence has also been obtained of "incompatibilities" and of stock preference with several of the common commercial varieties. And although at present it is not as easy as in the case of apples to control the size of the plum or peach tree by the influence of the stock during its development, it has been found possible to vary its period of blossoming and habit of growth by this means.

Thus the variability which was one of the chief obstacles to successful fruit growing has been brought under control and turned to account. It is possible for a grower to-day to predict with considerable exactitude over a wide range of conditions of soil, variety, etc., the approximate size to which an apple tree will grow, the age at which it will come into cropping, and even other factors such as its period of blossoming and its propensities to certain diseases and pests, and the size and quality of the fruit itself. There is also already sufficient evidence obtained from work on the stone fruits and citrus fruits to show that the day is probably not far distant when it will be possible similarly to control by means of the rootstocks all fruits grown as composite structures.—*International Review of Agriculture*, Year XXI, No. 5.

Plant Quarantine.

By Professor E. O. Essig, *University of California.*

The idea of quarantine* had its inception in connection with the attempts on the part of the early Europeans to exclude and prevent the spread of dreaded plague or black death. Venice inaugurated such a restrictive measure as early as 1348, which was followed by other European countries. In spite of the long experience of human health quarantine, England did not establish her first health quarantine until 1710, and delayed in passing the Public Health Act until 1896. Thus we see that many years have been required to perfect the present highly efficient and valuable public health measures now maintained by all the progressive nations of the world, and accepted by all their citizens. It is my firm belief that plant quarantine will, in a much shorter space of time, attain a similar place in the affairs of civilized peoples. Fundamentally it is as sound to protect the plant life of a country from the constant encroachments of insect depredators and plant diseases as it is to protect human health. An abundant and available food supply is as essential to human beings as is health and almost as personal, because it affects the livelihood of every individual, since the prices and availability of food are largely regulated by supply.

In view of the fact that there is so much general misunderstanding regarding plant quarantine, this article is written with the aim of presenting the claims of this young member of the administrative family.

In the first place, quarantine is a police power. This makes it very objectionable to certain minds. Anything that questions the free rights of individuals to act as they please is ever open to criticism. Law enforcement is always a difficult task, and even the most thoroughly qualified, tactful and resourceful official has great difficulty in handling the public as agreeably as is expected. Nearly all the complaints that arise from quarantine originate in regulatory and law-enforcement proceedings. This fact must be recognized at the outset. In this respect quarantine is no different from other measures enforced by due processes of Law.

Plant quarantine like health quarantine, was born of necessity; it was not the child of speculative philosophy, nor was it an ethical experiment. The early introduction into this country of such serious pests as the codling moth, San Jose Scale, citrus scale insects, cotton

* The term quarantine, literally meaning a period of forty days, was originally designated as the time during which a ship, suspected of being infected with serious contagious disease, was obliged to refrain from all intercourse with the shore. It has always come under the powers of the police,

boll weevil, pear psylla, cabbage worm, gipsy and brown-tail moths and many stored-product and household pests, as well as the rapid dissemination over the land of such native insects as the bean weevil, chinch bug, Colorado potato beetle, and other pests, were at first looked upon as a matter of course. But when it was learned that our system of agriculture, embodying the production of large areas of single crops, afforded unusually favourable conditions for these pests to propagate and do unheard-of damage, a new idea of insect immigration and migration was conceived on the proposition that exclusion is easier than extermination and cheaper than control!

With this idea in mind, the first State plant quarantine laws were promulgated and put into execution. The problem appeared easy at first, when there was but little knowledge of world economic entomology, when insect pests were supposed to be largely carried on nursery stock and when domestic and international commerce was slow and concentrated at the larger inland cities and at a comparatively few seaports. As a matter of fact, it was not difficult to enforce the laws as conditions existed then. But commerce developed faster than plant quarantine, which is well illustrated by the fact that a national conception of plant protection did not crystallize until 1912 with the passage of the first National Horticultural Law. This tardiness of action on the part of the Government permitted the free entrance into most parts of the country of many insects which seriously tax the agricultural welfare of the nation.

To prevent a continuance of this unwarranted spread of pests, plant quarantine has been thoroughly overhauled and strengthened. A number of important steps were recognized and taken. It was clear that to be effective such legislation should at least provide:

1. For the absolute exclusion of certain serious pests and all articles of commerce likely to carry them from known areas of infestation. This is virtually an embargo.

2. The right to destroy, reject or exclude materials when inspections reveal the presence of insect pests or plant diseases.

3. The right to prescribe restrictions and regulations under which plant materials may be admitted into a region.

4. The power to formulate plans and enforce regulations to confine an insect to a given area and to resist its spread from one district to another.

5. The authority, power and financial means necessary to discover and to exterminate, if possible, a pest newly established in an area.

This is a difficult and complex programme which requires expert training, skill and experience. Insects and diseases are carried in many

ways. When all these are learned some of the complexities will be removed. Years of careful study will be required to solve many of the problems of pest introduction and to perfect ways and means adequate to meet them.

It is impossible to predict what an insect will do in a new environment A great many of our worst pests were either unknown or of no economic importance in their native homes. Therefore plant quarantine can never be safely administered as a compromise measure.

In considering the above five points it would appear that complete exclusion is the most important, and at the same time most difficult to enforce. Such exclusive quarantines have been maintained against all products likely to carry pests from various districts throughout the world known to be infested with fruit flies, citrus canker, and the foot and mouth disease of live-stock. Plant pests and diseases as well as human diseases, such as plague, typhus and dysentery, do slip through such quarantine lines, but these failures are shallow arguments that such preventive measures are valueless and should be abandoned. As a result of such regulations the public becomes aware of the danger and the majority of those engaged in commerce or travel will co-operate to enforce the law, thus materially reducing the hazards of unknowingly bringing dangerous pests and diseases into the state or nation. Many of them will also actually assist in law enforcement. In this manner an insect pest may be kept out indefinitely or its entrance greatly delayed. Such delays enable the entomologists to study the insect and devise methods of control. There is every reason to believe that plant quarantine enforcement, together with the wide and continued publicity in the form of suitable literature placed in the hands of travellers, have been responsible for the fact that the Mediterranean fruit fly has not already been introduced in sufficient numbers into California from Hawaii to have become established here. The exclusion of the Mexican orange maggot and the cotton boll weevil are other instances which might be cited in this connection. If the insect finally slips through some leak it is more likely to be apprehended than in the days before quarantines were known, and the chances of exterminating it before it becomes widely distributed are very favourable—laws, trained men, improved methods of control, equipment like a well-trained and equipped army, are immediately available. In the case of health quarantine, plague occasionally enters our seaports in spite of the eternal vigilance of health authorities. Following this introduction an extermination campaign, at whatever cost eventually conquers it, and no one questions the expense. And, now and then a disease, like influenza, slips through the ports and sweeps

over the whole country. Does any one wish to abolish health quarantine because of such lapses?

In the early history of plant quarantine, inspection was the sole basis of admission or rejection of plant materials and is still an important part of present-day procedure, particularly in dealing with inter-sectional, inter-country and inter-estate movements of agricultural products. Inspection can never be 100 per cent. efficient because of the human limitations of the men doing the work. Yet it is the only means whereby produce can be moved with a degree of safety without paralyzing commerce. That very many serious pests are intercepted in this way is another indication that quarantine measures reduce the number of foci of infestation and thus delay a rapid spread over the entire country. Inspectors become more proficient and experienced from year to year, and it is to be expected that the service will thus be gradually improved.

The right to prescribe restrictions and regulations governing the admission of certain products results in no great inconvenience to the shipper and sets up safeguards for the protection of large districts against certain serious pests. Such safeguards in the form of restrictions and regulations are usually agreed upon before legal steps are taken, and all the cases I know of are carried out harmoniously and greatly to the benefit of all concerned. They furnish real financial incentives for those in infested areas to reduce the offending pests to the lowest possible minimum in order to secure more favourable regulations, or as in some cases, to cause them to be entirely withdrawn.

Circumscribing certain areas within a given part of the country which may be infested with a serious pest or disease is an important prerogative of quarantine. This method is commonly employed and is at the present time in force against the gipsy and brown-tail moths, Japanese beetle, European cornborer, date palm scales, Mediterranean fruit fly, citrus canker and similar insects and plant diseases. The idea is to prevent the artificial spread of such pests throughout the country by defining boundaries across which articles of commerce most likely to carry the pest cannot proceed. In the meantime everything is done through the employment of artificial biological methods of control to reduce the infestation and thereby reduce the natural spread, which cannot be stopped by legal processes of law. In this manner it is much more difficult for any of these pests to jump across the continent with plant products or other materials sent by mail, express or freight, or carried in private automobiles. As illustrations we might cite the cases of the gipsy and brown-tail moths, the Japanese beetle and the alfalfa weevil. All are gradually and slowly enlarging their boundaries, but none of them have

been able to make long-range establishments throughout the country. During the period of restriction all the more important facts concerning the life habits and control of all these pests have been ascertained and distributed throughout the country for the free use of all the people in meeting any like emergencies elsewhere. In these modern times the chances of distributing pests by means of automobiles and even aeroplanes offer probably the greatest hazards now faced by quarantine officials and thoroughly justify the entirely inadequate inspection stations found at some state and national boundary lines. When the private individual is aware of the importance of this service, the necessity for it will be greatly reduced and the inconvenience caused accepted without undue criticism.

The extermination of a serious pest, once thoroughly and permanently established in a new district, is a question of very great importance not only to the industries involved at the present time, but also to untold generations to come. It has often been argued that when once thoroughly established an insect pest cannot be eradicated. This fallacious statement has been based upon a few hard-hearted and inadequately and tardily financed attempts which were doomed to failure at the beginning. Eradication is possible if we as a county, state or nation are willing to pay the price. In this connection it might be well to call attention to the fact that quarantine officials in California have already discovered initial infestations of several newly introduced pests, including the pecan leaf case borer, the rough strawberry, weevil and citrus white fly, and have apparently successfully eradicated them at a cost so surprisingly low as to call forth no criticisms whatsoever. It now looks as though the campaign against citrus canker is also a case in point. The present campaign against the newly established Mediterranean fruit fly in Florida promises to furnish a glorious example of man's ability actually to exterminate a serious insect pest established over a large territory. Only the obstructionists can prevent its final consummation.

Imagine, if you can, an area comprising some 1,500,000 acres of fruit trees stretching across nine states with a total valuation of approximately $ 1,800,000,000 and an annual crop worth $ 240,000,000. This is the area and investment that is subject to possible injury and financial embarrassment by the Mediterranean fruit fly. No one will deny the right of the owners of these orchards to demand protection from the invasion of any insect pest which will add to the great expense already necessary to produce, harvest and market such a valuable crop. The comparatively small sum of $ 4,250,000 was appropriated to safeguard this great industry, which in reality belongs to the nation as a whole.

It has been spent as wisely as possible in an intensely important and feverish campaign conducted in a few months. The situation has been under orderly and complete control throughout the undertaking. The job has not been completed. No one acquainted with the problem expected it to be finished short of at least two cropping seasons. More money is needed to finish the task. Instead of an adequate appropriation to continue this work, $1,000,000 only has been made available. If this amount is not sufficient then other funds must be obtained, because this is one case where the actual financial considerations involved thoroughly justify the expenditure of large sums. This is a national problem and should be met as such. To embarrass financially or to ruin the fruit growers of Florida to accomplish the end in view not only is unjust, but might also result in the defeat of the project. Without the whole-hearted and sympathetic co-operation of these orchardists we cannot hope to destroy the very last fly.

Plant quarantine truly seeks to protect the agricultural resources for all the people. I refer to agriculture because the farmers more than any other class of people have been imposed upon by these foreign insect foes. They have been compelled to suffer great financial losses and to fight a continual and expensive campaign against insect pests and plant diseases. There is no discrimination on the part of the pest; every crop in every section of the continent is subject to their unrelenting attacks which result in absolute waste and therefore loss to the well-being of the entire country.

Is it any wonder then that the farmers have been positive in their demands for protection against additional hordes of insect pests? And even though many of the latter have already invaded the fields and orchards, are we not justified in our requests to close up the leaks and keep the others out? Plant quarantine can do this with proper legislation, judicious law enforcement, adequate financial support and the sympathetic co-operation of a well-informed public. It can never be absolute but it can be made to meet the agricultural needs of this country through capable and determined supervision.

Are we as a people to stand aside and watch the continued procession of destructive pests file into our country, sweep over our fields, orchards and forests, destroy our live-stock and invade our very homes on the shallow assumption that we are helpless because of certain uncontrollable biological factors? Or shall we challenge their right to such free aggressions by the enactment and enforcement of adequate plant quarantine measures? (*Science*, New Series, Vol. LXXI, No. 1840, April 4, 1930, pp. 350–353).—*Madras Agricultural Journal*, Vol. XVIII, No. 6.

The Story of two Decades of Chemical Research on Paddy Soils in the Madras Presidency.

By B. Viswanath.

Paddy or rice (*Oryza sativa*), being one of the principal food crops of Southern India occupying the largest portion of the cultivated area was the first to receive the attention of the Department of Agriculture since the commencement of Agricultural Research in this Presidency.

This article deals in popular language, with the investigations bearing on the study of the soil, the crop, the inter-relations that exist between soil conditions and crop growth, the mode of action of manures and the influence of manuring on the crop.

The practice of agriculture in its early days was based almost entirely on the results of accumulated experience. The cultivator had but little idea of the changes taking place in the soil or of the processes controlling the fertility of the land. In consequence he was often unable to circumvent adverse influences. In course of time, however, it was recognized that the factors involved in crop production were many and varied and the aid of science was invoked with the result that modern agriculture is a fabric built on a scientific foundation based on the labours of an army of investigators in a number of sciences all working in close collaboration with the practical farmer.

It is obvious that plants require food material for their growth and that as they thrive only in the soil, the food must come mainly from that source. The most important of these food constituents, from the point of their absorption by the plant in large quantities, are nitrogen, phosphoric acid and potash. Investigation has shown that all the plant food present in the soil is not in a form capable of being utilized by the growing crop. Plants can take in their food only when it is dissolved in water and that portion of the plant food in the soil which is not soluble in water is of little immediate benefit to the crop. It is, therefore, customary to speak of the 'total' and 'available' plant food in the soil, the latter being that portion which is soluble in soil water and which can be at once taken up by the crop. It is thus clear that the 'available' plant food in a soil is the factor of chief interest to the cultivator as, other conditions being satisfactory, its amount will, within certain limits, determine the yield of crops. The total plant food is not without interest to the ryot. It is in fact an item of reserve deposit from which small quantities are drawn from time to time. There is, in other words, a slow conversion of insoluble material into soluble plant food for the gradual use of the crop and it is this change which enables soils to go on producing crops for very long periods even though

no plant food is added in the form of manure. But if land is continually cropped, there must be a constant drain on the food supply present in the soil till it reaches a stage of minimum availability.

The yield from an acre of normal paddy crop (3,000 lbs. grain and 3,000 lbs. of straw) has been found to contain 48 lbs. of nitrogen, 23 lbs. of phosphoric acid and 41 lbs. of potash and these constituents must have come from the soil. If we visualize the soil as a bank, it is obvious that, unless what is withdrawn is returned, the account will soon be overdrawn. But wise Nature has foreseen man's greed and in her infinite wisdom has provided against his sins of commission and omission by setting up in the soil a mechanism for the indefinite supply of the bare minimum requirements, for what is ordinarily termed the minimum crop production. So that, if the few pounds of the manurial constituents taken off from the soil are not returned, there will not be a complete cessation of crop growth, but there will result crops poor in quality and quantity which means an inferior and insufficient food which in consequence produces a devitalized population falling an easy prey to all sorts of diseases.

It is a matter of great practical importance to ascertain to what extent the loss of plant food has proceeded, what reserves are available, and whether the soil is producing the maximum crop which it is capable of producing under proper management. To this end soil surveys of the more important paddy tracts throughout the Presidency were carried out. Many hundreds of samples, typical of the soils of each tract, have been collected and analysed. These surveys have yielded very striking results and show in a very marked manner how very deficient our soils are in certain ways and the large areas which demand immediate manurial treatment. The following tabular statement explains the nature and extent of the deficiency:—

No.	Name of Tract	Percentage of the soil deficient in	
		Nitrogen	Phosphate
1	Godavari	40	23
2	Kistna	33	55
3	Guntur	80	33
4	Tanjore	87	80
5	Periyar	0	90
6	Malabar	0	90

The surveys have, therefore, indicated, in a very definite manner the enormous loss in crop production which is taking place throughout the Presidency owing to the exhausted condition into which the soils have been allowed to fall, either through the ryot failing to appreciate the importance of manures or more usually through his inability to afford the cost of manures. Loss in yield, however, is not the only injury which results from the widespread deficiency of phosphoric acid. The results of experiments at Coimbatore have shown very clearly that in cases where phosphoric acid was deficient, not only was the yield reduced, but the composition of the crop was affected. Both grain and straw contained much less phosphoric acid than the crop from properly manured plots and hence the food value of the crop was much diminished.

The practical utility of the investigations mentioned above is obvious. With the aid of these soil analyses it has been found possible to ascertain the manurial needs of the areas and that of the paddy crop with the result that the nature of action of manures began to be investigated. The results of a large number of experiments in the field and in the pot culture house spread over a number of years have shown that all the natural and artificial nitrogenous manures are more or less beneficial to paddy but that they are more economical when applied in conjunction with bulky organic manures. Of the latter class of manures, green manures are pre-eminently suited to paddy crop. The results of the manurial experiments may be briefly described in numerical values comparing the relative merits of the different systems of manuring with that of green manure, taking the value of green manure as the unit of standard.

No.	Manure applied	Relative efficiency
1.	No Manure	0.33
2.	Phosphate alone	0.50
3.	Nitrogen alone	0.70
4.	Nitrogen *plus* Phosphate	0.90
5.	Green Manure	1.00
6.	Green Manure *plus* Phosphate	1.20
7.	Green Manure *plus* Nitrogen	1.33
8.	Green Manure *plus* Phosphate *plus* Nitrogen	1.60

Potash is not included in the investigations as our soils are generally well supplied with this constituent.

The numerical values mentioned above refer to the results of pot cultures. The results of field trials are of a simpler order.

These experiments show that of the three most important manurial constituents, namely, nitrogen, phosphoric acid and potash, the last named does not appear to be necessary except perhaps in rare cases or where it is indicated to counteract disease. Nitrogenous and phosphatic manures are in general need and are responded to by the crop when applied singly or together, but their effect when combined is better. Phosphatic manures have been found to stimulate the assimilation of nitrogen which would otherwise not be utilized and also to enrich the composition of the crop in this constituent thus enhancing the nutritive and seed value of the grain.

It is seen that artificial manures are not as efficient as green manures for paddy and that the efficiency of either class of manures can be considerably improved by combining them. This raises the question as to the proportion in which artificials and green manures should be used. In so far as the Coimbatore soils are concerned, it would appear that a mixture of two-fifths of artificial nitrogen and three-fifths of organic nitrogen make a suitable combination for paddy. Larger dressings of green manure appear to render supplements of artificial nitrogen like sulphate of ammonia ineffective.

The study of the soil conditions and the nutrition of the paddy plant with special reference to the practice of green manuring marks a distinct advance in our knowledge of the nature of action of green manure under puddled and swampy conditions.

Paddy in this Presidency is generally grown under swampy conditions and in a puddled soil throughout the growing season, and yet no general system of cultivation holds good for all tracts, so that it cannot be said that the system adopted in one locality holds good in another. In South Malabar, the general practice is to plough the lands in the dry season with excellent results, but this practice introduced into the deltaic tracts resulted in failure. Green manuring is found beneficial in one area but when tried in another the crop fails. In some places water may be run on to fields and puddling and manuring done weeks before the crop is planted, but in other districts the custom is to put in the green manure just before transplanting. These and other mutually opposed facts make it essential that the conditions governing the growth of paddy should be closely studied in order to obtain, if possible, some common basis capable of explaining them before any improvements in paddy cultivation can be considered.

Since green manure undergoes putrefactive fermentation when buried under water, it was considered that an examination of the soil gases would make an opening to the problem. The first investigation

showed that the normal fermentation of green manure in swamp paddy soils leads to the production of different gases and that the introduction of a crop into the field modifies the proportion in which some of the gases are produced and inhibits the production of others. The soil conditions are found to be anærobic in character and therefore, nitrification is impossible and the nitrates produced during the period when the soil was dry are quickly denitrified. Under these conditions, therefore, the nitrogen required by the crop is obtained in the form of ammonia and probably from other nitrogenous organic compounds produced by the anærobic decomposition of the proteins in the green manure.

Certain substances formed as a result of this decomposition are toxic to the crop and should be removed in the drainage water or should be destroyed by prolonged decomposition before seedlings are transplanted.

A more detailed study of the soil gases has revealed the fact that the gases escaping through and at the surface of the water in the paddy fields, are different from those that are present in the soil themselves and consist mostly of oxygen and nitrogen as against marsh gas, hydrogen and carbon dioxide that are formed in the soil. A certain relationship was also noticed between the evolution of oxygen and the presence or absence of crop, and pot experiments have clearly shown that the effect of the crop is to diminish the evolution of oxygen. This means that the evolved oxygen is absorbed by the crop for its growth. A careful examination of paddy roots of different types has shown that the roots of paddy do not resemble those of typical aquatic plants, but are similar to those of ordinary dry land crops and as such require oxygen to be healthy and strong. The supposition is, therefore, correct that the oxygen is used up by the crop for ærating its roots.

The evolution of oxygen has been traced to a film of algæ commonly seen on the surface of paddy fields and this film is found to contain bacteria which oxidize hydrogen and marsh gas with production of carbon dioxide. The carbon of this gas is utilized by the algæ for this food-liberating oxygen which dissolves in the soil water and ærates the roots.

If the oxygen dissolved in the surface water is to ærate the roots, the water charged with oxygen should be capable of reaching the root zone, and this is possible only if there is drainage; so that drainage is an important factor. If the soil is badly drained the oxygenated water cannot enter the soil and consequently æration would be restricted to the surface layers.

On the other hand, in well drained soils, the ærated water would penetrate deeper into the soil. Consequently it appears reasonable to presume that the better the drainage, the deeper would be the æration and therefore a proportionately increased cropping. If this is the case æration can be promoted by a thorough periodical draining of the soil.

Actual experiments have shown that this is not the case. The mere draining of the soil is inadequate for the purpose. The simple system of slow movement of water through the soil and therefore through the root range has been found to be most beneficial for the crop. The reason for this has been found to be that the water percolating through the soil is strongly charged with oxygen and therefore supplies plenty of it to the roots; whereas, the simple admission of air into the soil by thorough draining would yield only a weak solution of oxygen.

The best results are obtained with a moderate amount of drainage and too slow or too rapid drainage would result in decreased cropping. The reason for this has been traced to the fact that the development of the film which is responsible for the supply of oxygen occurs best under moderate drainage conditions. Thus the most efficient drainage in paddy soils is not the quickest but one that permits the surface film to maintain its full activity.

The practical aspect of these investigations from the point of view of the South Indian ryot is that the relationship of green manure to the æration of roots is of the greatest importance and that, apart from all other considerations of manurial value or its influence on the texture of the soil, one of the most important functions of green manuring with reference to paddy soils lies in promoting the activity of the surface film which is responsible for the proper æration of the roots. We have also learnt that green manuring does not always give good results on all soils and that when drainage is deficient, the toxins produced during the decomposition of the green manure affect the growth of the crop adversely and that, therefore, green manuring should not be adopted as a universal practice but should be undertaken after careful consideration. The universal practice of puddling paddy soils has been understood and this knowledge has led to the conclusion that drainage can be controlled by means of puddling and that this is easily at the command of the ryot.

Another very important practical indication of these investigations is that growing a green manure crop in a field to which it has to be subsequently applied as green manure, is not advantageous as the nitrogen is largely dissipated as gas and as the crop had taken its nitrogen originally from the soil, it involves a distinct loss of nitrogen.

The work on paddy soils and the nutrition of the paddy plant has so far been considered. The work on the dietetic value of rice which forms the main food of a large section of the people of South India will now be considered. This investigation had its origin in a collaborative work of the chemical section with the Deficiency Diseases Inquiry into the relationship existing between rice and Beri-beri in India.

The problem of the relationship of rice to Beri-beri will not be specifically discussed here but certain aspects of the defects of polished white rice will be briefly considered.

Fashion is so contagious that even the poorest man is anxious to use highly polished spotless white rice if he could only secure it. It is no exaggeration to state that the opulence and the extent of refinement of a man is partly measured by the quality of the rice he uses. Little do we know what valuable nutrient materials are lost in the polishing. The greater the polish, the greater is the loss. The fats, proteins, mineral salts and vitamines are stored in the outer, dirty brown or red coating of the rice grain, and during the process of polishing these nutritive constituents are lost and all that remains is mostly starch.

Analyses in the laboratory and feeding trials with pigeons have shown that raw-milled, unpolished rice is the most nutritious, while raw-milled, highly polished rice is the least nutritious. Parboiled rice comes midway between these two extremes. Parboiled and milled rice, in the unpolished stage, is not so nutritious as raw-milled and unpolished rice: but even when it is polished, boiled rice possesses a higher nutritive value than the corresponding raw polished rice.

Washing of rice just before cooking has also been found to deprive rice of a good deal of its most nutritious ingredients. The effect of draining rice after cooking should also be similar.—*The Madras Agricultural Journal*, Vol. XVII, No. 11.

THE MYSORE AGRICULTURAL AND EXPERIMENTAL UNION.

Programme of Experimental Work for 1931.

CIRCULAR.

The Department of Agriculture desires to arrange with members of the Mysore Agricultural and Experimental Union for the carrying out of the experiments mentioned below. Members intending to undertake experimental work are requested to apply to the Secretary, The Mysore Agricultural and Experimental Union, Seshadri Road, Bangalore, before the 15th January 1931 marking out the experiment or experiments they desire to undertake on this circular itself. The seed, manure, etc., will be supplied in the order in which the application is received as long as the stock lasts.

1.—Experiments with Seeds.

Trial of selected strains of—

(*a*) Ragi—seed enough for 3 guntas each of two new varieties will be supplied.

(*b*) Groundnut—seed enough for 3 guntas each of one or two new varieties will be supplied.

(*c*) Cotton :

(1) Doddahatti—seed enough for 3 guntas will be supplied.

(2) Sannahatti—seed enough for 12 guntas each of two varieties will be supplied. (Trials confined to cotton areas only.)

(*d*) Paddy—seed enough for 3 guntas each of two varieties will be supplied.

(*e*) Sugarcane—seed enough for one gunta each of two Hebbal seedling canes will be supplied. Arrangements for the conveyance of seed setts from the nearest railway station should be made by the member indenting for them. Applications for sugarcane setts should be made so as to reach the Secretary before the 15th January 1931 stating the probable time the setts should be supplied.

Conditions of Supply of Seed.

1. The seed of each variety shall be sown in separate plots with check plots arranged as per instructions sent with the seed.
2. The results of experiments shall be reported after harvest in the form which will be supplied.
3. The experiments shall be conducted continuously for at least three years, seeds for the second and subsequent sowings being reserved from the first supply by the Agricultural Department.

2.—Experiments with Manures.

I. Sugarcane—Comparative trial of 80 lbs. of ammonium sulphate and 3 cwts. of superphosphate per acre applied before planting and 160 lbs. of sulphate applied again about 10 weeks after planting, against—

1. Only 3 cwts. of super at planting and 240 lbs. of sulphate about 10 weeks after planting, *or*
2. 100 lbs. of Ammophos 13–48 grade at planting and 160 lbs. of sulphate of ammonia 10 weeks after planting, *or*
3. 100 lbs. Nicifos 17–45 grade at planting and 160 lbs. of sulphate of ammonia 10 weeks later on.

Not less than 10 guntas of land will be required.

II. Paddy—Trial of 250 lbs. of groundnut cake and 1½ cwts. of super per acre against—

(*a*) 120 lbs. Ammophos 20–20 grade, *or*

(*b*) 100 lbs. Nicifos 22–18 grade, *or*

(*c*) 100 lbs. Nicifos 17–45 grade.

Not less than 10 guntas of land will be required.

3.—Areca.

Trial of a mixture of 400 lbs. groundnut cake, 100 lbs. concentrated super and 120 lbs. muriate of potash per acre of 400 bearing trees against—

(*a*) 160 lbs. sulphate of ammonia, 100 lbs. concentrated super and 120 lbs. muriate of potash, *or*

(*b*) 200 lbs. Ammophos 20–20 grade and 120 lbs. muriate of potash, *or*

(*c*) 150 lbs. Nicifos 17–45 grade and 120 lbs. of muriate of potash.

A minimum of 180 bearing plants are required for the purpose.

Such manures as are available, excepting oil-cake, will be given free. Oil-cake will have to be purchased by the member.

4.—Experiments on the Control of Insect Pests.

(*a*) Sugarcane Borer.
(*b*) Pests of Stored Pulses.
(*c*) Pests of Stored Paddy.
(*d*) Coffee Borer.
(*e*) Cardamom Caterpillar.
(*f*) Lime-tree Borer.
(*g*) Avare Pod Borer.

} Printed instructions will be sent on requisition.

5.—Experiments on the Control of Fungus Diseases.

(*a*) Treatment against Smut on Jola.

(*b*) Spraying against *alternaria* disease of potato.

6.—Experiments on Fodder Conservation.

Use of sunflower, jola and other fodder crops for ensilage. Printed instructions will be sent on requisition.

BANGALORE,
16—12—1930.

LESLIE C. COLEMAN,
President,
The Mysore Agricultural and Experimental Union.

DEAR SIR,

I desire to undertake the experiments ticked off on the circular during the coming season. I have conducted the experiments undertaken by me last year properly. I agree to conduct the experiments and report results as required during the present year. Please arrange to supply the requirements.

Station.....
Date.....

Yours faithfully,

Signature and Address of the Member.

2926-30 Printed at the Bangalore Press, Mysore Road, Bangalore City.

Index Map of Irwin Canal Showing Maddur Branch Irrigation Tract